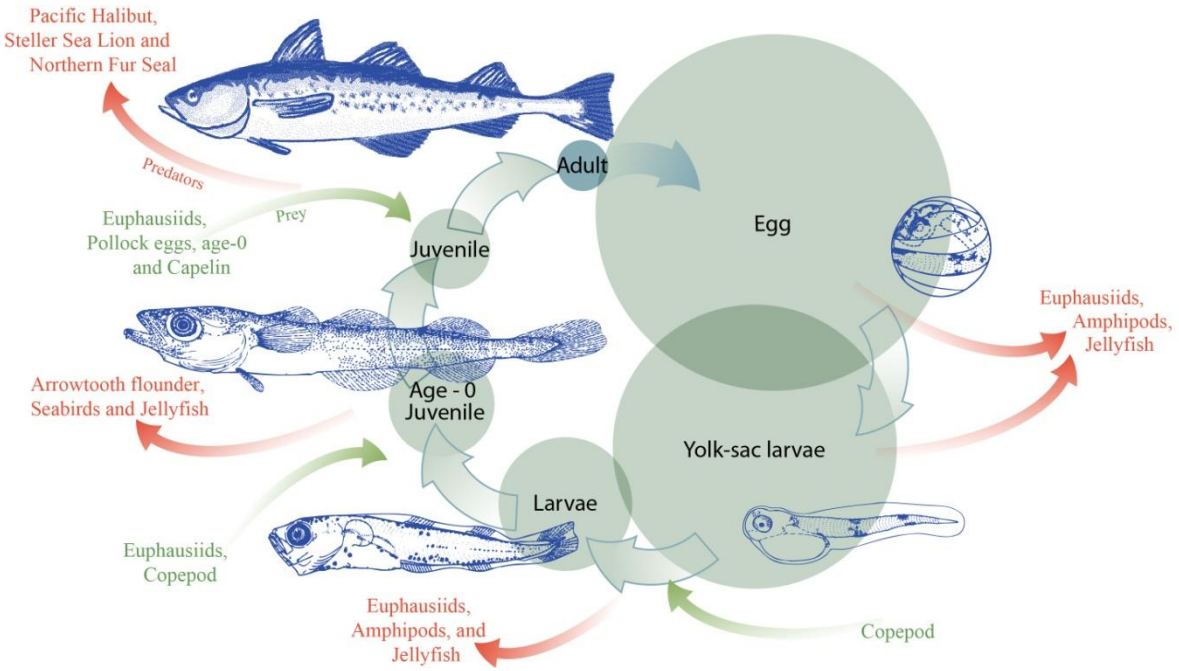
Science behind Sustainable Seafood: Survival in a Dangerous Environment!

Brief Overview

The life cycle of pollock takes it on a wild adventure through dangerous water and dangerous predators. This lesson will help the students explore the stages of a pollock life cycle and the dangerous factors that influence their survivability. Students will play the "Pollock Survival Game" to learn why a pollock needs to spawn millions of eggs in order to perpetuate the species. Dangers lurk in the ocean environment from temperature, to currents and even ocean acidification and danger lurks in the mouths of the predators looking to eat pollock for dinner.



Survival in a dangerous environment

Take a spin around the walleye pollock life cycle:

Imagine that you are a walleye pollock egg adrift in the cold waters of Alaska. You are only slightly larger than a pinhead. In order to survive you must overcome big challenges. You are not only fragile, but vulnerable to changing ocean currents and temperature. Ocean temperatures may limit or increase your growth potential. Strong ocean currents can sweep you far out to sea where prey is scarce and you may starve. You don't have to worry about food until you hatch because your yolk sac has been supplying you with precious nutrients. A few days after hatching your yolk sac is empty and you now must swim and search for food. Even as you search for prey, you are also prey for many predators such as jellyfish, euphausiids (krill), and not to mention small fish. As you get older new predators like arrowtooth flounder find you appetizing. If you should find good ocean conditions, find lots to eat, and manage to escape being eaten, then there's a good chance you will grow up to be an adult to contribute by spawning the next generation of fish. If too many young pollock don't survive to adulthood, then

there is a possibility the population of pollock will decrease in the future. This would mean lower quotas for fishermen to ensure pollock populations are kept at a sustainable level.

Big Ideas: Pollock survival, throughout its life cycle, is influenced by many ecosystem factors.
Essential Question: How does the ecosystem influence survivability of pollock through its life cycle?
Objectives: The student will be able to explain pollock life cycle and how ecosystem factors relate to recruitment to the fishery (adult population).

Key Subjects/Standards

National	**Science**: NS.9-12.1 Science as Inquiry. NS 9-12.3 Life Science: Interdependence of organisms, Behavior of organisms. NS 9-12.6 Personal and Social Perspective: Population growth, Natural resources, environmental quality. **Math:** NM-NUM. 9-12.3 Number and Operations: compute fluently and make reasonable estimates. NM-PROB.CONN.PK -12.3 Connections: recognize and apply mathematics in contexts outside of mathematics. **Economics:** NSS-EC.9-12.1 Scarcity. NSS-EC.9-12.4 Role of incentives. **Social Sciences:** NSS-G.K-12.2 Places and Regions. NSS-G.K-12.3 Physical Systems.
Ocean Literacy	5. The ocean is filled with diversity. 6. The ocean and humans are inextricably interconnected (b, c, e, g).

Teacher Preparation

1. Read the entire activity and review all background material and resources.
2. Determine the amount of time you would like to dedicate to this activity. If classroom time is readily available, a minimum of two 50-minute classroom periods is advised. If classroom time is limited, students may complete some of their tasks as homework.
3. Determine the best assessment strategy for your class based on suggestions made by authors.

Materials List

- Pollock life cycle graphic
- Game board graphic to draw on large paper or project
- Index Cards or Avery 8371 matte, perforated business card for inkjet printers (~$13=$15 per pack)
- Dice
- Place markers (game pieces)
- Flexa-hexagon of Pollock life cycle – can be ordered see bleow.
- PDF with information about Pollock Early Life History distribution - here.
- Contact afsc.outreach@noaa.gov for materials.

Background

Walleye pollock make up the largest by volume fishery in the U.S. The fishery as well as the center of their abundance is located in the Bering Sea, a smaller fishery happens in the Gulf of Alaska. They are in the gadid family with other cod and cod-like species and live in large schools about 300 to 1000 feet below the surface of the ocean. They are an important part of the Bering Sea ecosystem as predators and for providing a source of food as prey for many species of animals.

Throughout their life history pollock populations are also influenced by many environmental factors. These include oceanographic factors such as currents, temperature and nutrients. One of the more influential environmental factors affecting pollock survival is at their larva stage. The success of pollock at the larval stage is dependent on the spring plankton bloom where microscopic plants called phytoplankton begin growing in the ocean. When the bloom begins depends on factors such as the amount of sunlight, nutrients and temperature of the water. The spring phytoplankton bloom is important because it supports reproduction of copepods that are a source of food for walleye pollock. Copepods are small animals, the size of a grain of rice, called zooplankton. Zooplankton feed on phytoplankton, as do their eggs, called copepod nauplii, which are the food source of the larval pollock. If the spring plankton bloom does not occur near of during the time when the larvae are ready to eat, then their survival will decrease.

Recruitment for commercially fished species occurs when they grow to the size captured or retained by the nets or gear used in the fishery. For each species or ecosystem component that we study, we attempt to learn what biotic

and abiotic factors cause or contribute to the observed population fluctuations. These population fluctuations occur on many different time scales (for example, between years, between decades).

What are a pollock's life stages?

Egg

Beginning in late winter, trillions of tiny walleye pollock eggs are spawned near the bottom in specific areas in Alaska waters. In the Gulf of Alaska, pollock spawn in Shelikof Strait and in the Bering Sea they spawn around the Pribilof Islands and along the Alaska Peninsula. These eggs will drift for two weeks impacted by currents and predators.

Larva

When larvae (plural of larva) first hatch they rely on food stored in a membranous pouch under their bodies called a yolk sac. While their eyes, stomachs and mouths develop the yolk sac is their only food source for about a week after hatching.

Once the yolk sac is consumed the larvae, still tiny at about 5 mm in length, catch their own food as they drift with the ocean currents. For about three months the larvae will continue to grow.

Age-0 Juvenile

After their larval stage and before their first birthday, walleye pollock are called "Age-0 (zero)" and measure about 5 inches in length (about 13 cm). These juveniles are an important food source for sea birds, jellyfish and even adult pollock.

Juvenile

Walleye pollock are considered juveniles until they have developed enough to spawn (**3-4 years**). Juvenile fish in the Gulf of Alaska spend their time near shore in coastal bays and estuaries known as nursery areas and in the Bering Sea they have no place to hide.

Adult

Walleye pollock mature into adults at 3 to 4 years of age and are about 14 inches (35 cm) long. Adults can live up to **17 years**, and can grow as large as 3 ft in length (1 m).

Instructional Strategies/Procedures

Activity 1A - Engagement Pollock Life Cycle (50 minutes)

1. Before starting the discussion about pollock life cycle, have a discussion with the students on what the different stages in the life history of a human being are.
    1. Discuss how those stages are defined. Are you using age? Height? Grade level in school?

2. Using the pollock life cycle graphic, go through the life history of pollock. At each life stage discuss with the students what environmental factors may be detrimental to the success of the pollock to survive to the next life stage. Explain that population health is influenced
3. Spend about 15-20 minutes and have students create their own pollock flexa-hexagon that illustrates the pollock life cycle, their prey and their predators.
    1. Have students come up to the front of the class and give an example of pollock prey and predators using the flexa-hexagon.

Engagement

Activity 1B - Pollock survival game (50 minutes)

1. Play Pollock survival game - this is a table top game or projected on a screen or smartboard that uses the image of Shelikof Strait in the Gulf of Alaska. This is where a large spawning aggregation of pollock occurs every winter.
2. Premise: You are a walleye Pollock egg in the ocean and your goal is to become an adult. In order to do this you need food and optimal ocean conditions and avoid being eaten by predators.
3. Each student begins as a pollock egg in Shelikof Strait. Give each student a game piece to move through Shelikof Strait as they get older.
4. Start the game off in reverse alphabetical order. Students with last name beginning with Z start first!
5. At each turn a player picks a predator card, to see if they survived being eaten. If they are not eaten then they get to roll the die.
    1. Predator Cards – can be written on index cards or use the supplied business card layout to print on an inkjet or laser printer. 30 cards total.
        i. Fishing Vessel (x3) You have been caught in a fish net. If you are an adult you die.
        ii. Jellyfish (x3) You have been eaten if you are a yolk-sac larva, larva or age-0 juvenile.
        iii. Seabirds (x2) You have been eaten if you are an age-0 juvenile.
        iv. Euphausiid (x3) You have been eaten if you are an egg, yolk-sac larva or larva.
        v. Amphipod (x2) You have been eaten if you are an egg, yolk-sac larva or larva.
        vi. Fish (x3) You have been eaten if you are an age-0 or juvenile.
        vii. Marine mammal (x2) You have been eaten if you are a juvenile or adult.
        viii. Euphausiid (x2) You have escaped being eaten.
        ix. Amphipod (x2) You have escaped being eaten.
        x. Fish (x2) You have escaped being eaten.
        xi. Jellyfish (x3) You have escaped being eaten.
        xii. Seabird (x2) You have escaped being eaten.
        xiii. Marine Mammal (x1) You have escaped being eaten.

6. The number on the die represents an oceanic condition that may hinder their survival.
    1. Jellyfish bloom – pollock yolk-sac larva and larvae lose a turn.
    2. Current shifts – eggs and larvae are lost at sea and lose a turn trying to get back.
    3. Sea surface temperature is 2 degrees colder all pollock are happy. Move to next stage.
    4. Sea surface temperature is 8 degrees warmer – pollock eggs lose a turn.
    5. Late spring bloom – Pollock age-0 die.
    6. Increase in Ocean Acidification decreases number of euphausiids – pollock larvae die. Adult pollock are eating more age-0 juvenile who lose a turn trying to swim away.
7. On white board or flip chart record:
    1. # of deaths per life stage
    2. # of turns
    3. # of survivors to Adult

4. # of spawners - Adult has to survive 2 turns in order to successfully spawn.

8. After 50 turns (50 eggs) the game is over.
9. Tally the numbers and have a discussion of what environmental factors have greatest impact on pollock population.
10. Record in excel spreadsheet –Deaths and Total number of eggs at egg stage, yolk sac stage, larvae, age-0 juvenile (young of the year), juvenile, adult. Create graphs to illustrate how many of the total number of eggs survived or died at each stage.
11. Ask questions such as:
    1. If fishing stopped is it guaranteed that the pollock population would go up?
    2. How will increasing ocean temperatures affect pollock population?
    3. Will Ocean acidification have a role in pollock survival? (What is a copepod made out of?)

Extensions & Connections

- Read pollock larvae mortality paper by Bailey and Macklin – elaborate on what influences larvae mortality that may be different than what was in the game.
- Read Influence of environment on pollock by Smart et.al. – Discuss how more environmental factors can be incorporated into the survival game.

Assessment

Lab write up
Complete game
Recording data
Data analysis

Vocabulary: Life history, life stage, mortality, predation, recruitment, amphipod, euphaussiids, predator, current, plankton, zooplankton, phytoplankton, climate, marine mammals, proportion, jellyfish, static, dynamic.

Possible Misconceptions

Food resources for fish are unlimited.
Ocean is static environment – not dynamic.
All eggs hatched survive to adulthood.

Reflection on Roles

Have students break up into their groups – Industry, scientists, concerned citizens and council members. Have them reflect on what today's lesson may be relevant to their supporting statements they will be giving to the council members. Council members can reflect on what they would expect to see from each group.

Project Evaluation

At the end of the project the teacher should fill out the SBSS Evaluation sheet.

Resources for Teachers

Climate and Fish Sticks article
Bloom or Bust: The bond between Fish and Phytoplankton - http://earthdata.nasa.gov/featured-stories/featured-research/bloom-or-bust-bond-between-fish-and-phytoplankton
SeaWiFS (Sea-viewing Wide Field-of-view Sensor) - Teacher resources - http://oceancolor.gsfc.nasa.gov/SeaWiFS/TEACHERS/
Instructional video about ocean surface currents http://www.watchknowlearn.org/Video.aspx?VideoID=13205